reinforcement learning: planning and control through experience

Gavin Taylor

United States Naval Academy

Annapolis, MD 21401

Abstract

Significant recent advances in Machine Learning have resulted in an explosion of interest in the field and its possible applications. Reinforcement Learning is a sub-field of ML which attempts to address the control question, including in the control of difficult-to-model, dynamic systems. Reinforcement Learning has undergone particular growth, with several recent high-profile successes. In this paper, I introduce the field of Reinforcement Learning, and describe its strengths and weaknesses to help the reader understand if the approach is appropriate for their control problem.

Keywords

Reinforcement Learning, Control Theory, Machine Learning, Artificial Intelligence.

Introduction

The layout and style to be adopted in the preparation of your paper are described and illustrated through an example. ***Authors are requested to strictly adhere to these instructions***. If you are already familiar with Word, then the FOCAPD 2019 template should be of great help for you since it will change the layout so as to suit FOCAPD 2019 requirements. Nonetheless, the use of the document template is not mandatory.

Authors are expected to submit their paper by   
December 1, 2018. Only PDF files will be accepted for upload. The papers should be prepared if possible using Microsoft Word. LaTex can be used provided the format is similar to the one of this template.

As an author, you are fully responsible for the quality and appearance of your contribution. We request that you observe carefully these instructions for preparing your manuscript. *In almost all situations, use of the built-in template styles will save you from the grim details of fonts, sizes, line spacings, indentation, etc.* Failure to produce a paper in proper format will involve: (1) a request for a reformatting to meet the standards, or (2) the possibility that your contribution will not appear in the final Conference Proceedings.

Problem Statement

Imagine a child learning to ride a bicycle. From their senses, the child is confronted with a continued stream of useful information that describes the current state of their bicycle-riding adventure. For example, this data includes the angle of their handlebars, the amount of weight being shifted from one side of the bike to the other, the speed at which the bicycle is being ridden, an observation of the type of surface being ridden on, and any pain in their knee there may be from previous falls and scrapes. After many experiences and experiments, the child has sufficient data to learn to ride, maximizing the positive parts of the experience (euphoria from speed and independence, parental congratulations), while minimizing the negative aspects (falls, scrapes, embarrassment).

Mathematically, we attempt to describe this problem with a Markov Decision Process (MDP). An MDP is a tuple , where  is the set of all states the problem might be in (in the case of a bicycle, this could include angle from upright, the angle of the handlebars, the current speed, the road surface, etc.),  is the set of all actions the agent can take (turn the handlebars, pedal at some speed, etc.),  is a transition kernel describing the probabilities of transitioning between two states when performing an action (, where 

Printing Area

Each letter size page must be formatted with left/right margins of 0.83”, top margin of 0.75” and bottom margin of 0.5”. The text should be justified so that the right margin is not ragged. Please make use of the maximum stipulated length (*9.75”*). Thus, approximately 57 lines can be written on a full-text page. Length of the text should never be less than *9.25”*. **No headers, borders or page numbers should be included**. Page numbering in the final manuscript should be allocated by the volume editor.

Layout, Typeface, and Font Sizes

Times New Roman or Times font should be adopted. If not strictly required, bold type and underlining should be avoided. A summary of the required font sizes and styles is given.

Title 14 pt

Footnote reference 9 pt

Footnote text 9 pt

Reference 9 pt

Elsewhere 10 pt

Font styles are as follows:

Title **BOLD** capitals

Abstract heading *italic,* mixed case

Keyword heading *italic,* mixed case

Figure caption *italic,* mixed case

Table caption *italic,* mixed case

Main heading **bold***,* mixed case

Sub-heading *italic,* mixed case

Elsewhere normal

Authors and Affiliations.

Authors’ names must include the first and middle names initials followed by the last name. They should be centered and separated by commas. A superscript set on each author’s name should be used to indicate his/her affiliation. Names and addresses of their institutions should also be centered. The corresponding styles are *Author, Affiliation, Location*.

Abstracts and Keywords.

Start with *Abstract* *Heading* style and then include the abstract body (*Abstract Body* style) with a brief (100-200 words) description of the most relevant contributions of the paper. The content of the abstract should be written without changing line. For **Keywords**, continue with *Keywords Heading* style. Three keywords (*Keywords Body* style), capitalized and separated by commas, should be included.

Paper Body

The main text should be typed single spaced and justified. The first line of each paragraph should be indented 5 mm from the left margin. No line spacing should be left between paragraphs. The style for the first paragraph is *First Paragraph*. For all other paragraphs use *Norml* style.

Section Titles

Titles should only be assigned to sections and subsections. Section titles should be capitalized (i.e., nouns, verbs, and all other words except articles, prepositions, and conjunctions should be set with an initial capital), boldface and, with the exception of the paper title, left aligned. Use *Main Heading* style for section titles.

Subsection Titles

For the subsection title use *Subheading* style.

Tables and Illustrations

Please produce your figures electronically, and integrate figures and tables into your text file. Figures, tables and photographs should be placed as close to their first reference in the text as possible. Figures and Tables should be numbered using Arabic numerals. Tables should be presented in the form shown in Table 1.

Table 1. Font sizes and styles

|  |  |
| --- | --- |
| Heading level | Example |
| Title (centered) | **Authors’ Instru…** |
| Main heading | **Introduction** |
| Subheading | *Subsection titles* |
| Main Body | Text follows … |

Keep figures and tables within a singe column, if possible. For larger objects Word requires that you create and format a new page-wide section that is identical in format to the first page-wide section (the one containing the title, author information, abstract, and keywords). Use *Normal* style for tables and *Figure* style for figures.

Tables and captions should be centered, with the caption located just above the table. Vertical lines should be avoided. Labels for every row and column and proper units for the data should be given.

In the same way, figures should be centered and numbered, with each one having its own legend. The legend should be centered right below the figure (see Figure 1). Labels for plot coordinate axes and proper units for the data should be given. Grids and details within the figures must be clearly readable and may not be written one on top of the other. The lettering in figures should have a height of 2 mm (10-point type). If you have to insert a page break before a figure, please ensure that the previous page has been completely filled. Finally, a couple of recommendations: (a)Remember that illustrations in the Proceedings will be black and white (halftones). (b)Avoid using shading. For captions use *Table Caption* and *Figure Caption* styles.



Figure 1. This is the figure caption

Equations, symbols and units

Equations should be left aligned on a separate line and numbered with an Arabic numeral placed within parentheses and right aligned. For example,

 (1)

In the text, Equation (1) should be referred to as Eq. (1), except at the beginning of a sentence where Equation (1) should be used. Use *Equation* style for equations.

Footnotes

The superscript numeral used to refer to a footnote should appear in the text either directly after the word (phrase or sentence) to which is related, following the punctuation sign (comma, semicolon, or period). The footnotes should appear at the bottom of the normal printing area, with a line 2 cm long set immediately above them.[[1]](#footnote-1) This is done automatically if you use *Footnote Text* style.

Acknowledgments

This section should be placed at the end of the paper before the **References** section. This section should include acknowledgments of financial, institutional and personal support.

References

References (*Reference* style) should be listed in alphabetic order by surname at the end of the paper following the section title **References** right after the Acknowledgment section. Do not begin a new page with the Reference section unless it is absolutely necessary. The References section, with the exception of the title, should be typed in 9-point font. Each line of a reference, except the first, should be indented 0.5” from the left margin. All references included in the list should be cited in the text and vice versa. References are to be cited in the text by author’s name (year), or (authors’ names, year). For instance, Smith and Jones (1970), or (Ekeland et al., 1985). The expression et al. should be used when there are three or more authors. Two or more papers by the same authors published in different years should be chronologically arranged. Two or more papers by the same authors published in the same year should be distinguished by letters after the year.

Brooke, A., Kendrick, D., Meeraus, A. A. (1992). GAMS- A User's Guide (Release 2.25). *The Scientific Press*. San Francisco, CA.

Gooding, W. B., Pekny, J. F., McCroskey, P. S. (1994). Enumerative Approaches to Parallel Flowshop Scheduling via Problem Transformation. *Comput. Chem. Eng.*, *18*, 909.

OSL. (1991). *OSL, Guide and Reference (release 2)*, IBM: Kingston, NY.

Zhang, X., Sargent, R. W. H. (1994). The Optimal Operation of Mixed Production Facilities - A General Formulation and some Approaches for the Solution. *In Proceedings of the 5th International Symposium on Process Systems Engineering*. Kyongju, Korea, 171.

1. The footnote numeral is set flush left and the text follows with the usual word spacing. Second and subsequent lines are indented. Footnotes should end with a period. [↑](#footnote-ref-1)